Angle Lake Water Quality

A Report on Water Quality Monitoring Results
for Water Year 2011 at Angle Lake

Angle Lake *photo by Lake Stewardship Program*

Prepared for the City of SeaTac
by the King County Water and Land Resources Freshwater Program

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King County

Overview

Volunteer monitors on Angle Lake have been working with King County Water and Land Resources (WLRD) since 1994, although monitoring data collected by METRO goes back as far as the 1970s. There was a break in monitoring during 1996, but work resumed in 1997. In 2005, the City of SeaTac contracted with WLRD to continue volunteer monitoring of Angle Lake. During the 2011 water year, four citizens volunteered their time to continue monitoring on Angle Lake. The water quality data indicate that currently the lake continues to have low productivity categorized as oligotrophic, with very good water quality.

Angle Lake is popular for fishing, boating and swimming. The lake has a well-used public access boat ramp, and residents may want to monitor aquatic plants growing nearshore to catch early infestations of Eurasian milfoil, Brazilian elodea or other noxious aquatic weeds, which are often transported by boats and boat trailers.

This report refers to two common measures used to predict water quality in lakes. The Trophic State Index or TSI (Carlson 1977) is a method of calculating indicators from collected data that allows comparison between different parameters and predicts the volume of algae that could be produced in the lake. A second measure is the nitrogen to phosphorus ratio (N:P), which is used to predict which groups of algae may become dominant in the lake during the sample period. Both the TSI and N:P ratios have been calculated using the available data collected through the volunteer monitoring program.

The discussion in this report focuses on the 2011 water year. Specific data used to generate the charts in this report can be downloaded from the King County Lake small lakes data website at:
http://your.kingcounty.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx

It can also be provided in the form of excel files upon request.

Physical Parameters

Excellent records of precipitation and water level were kept over the 2011 water year (Figure 1). The lake level followed a pattern commonly found in the Puget lowlands of winter high to summer low stands, with some sensitivity shown to inputs from large rain events, particularly in winter. The lake ended the water year about 25cm higher than it had been in September 2010 and 50 cm higher than September 2009. This possibly can be attributed to two successive La Nina weather patterns hitting the northwest, providing wetter winters and springs that kept area lake levels higher. Water levels at Angle Lake have not been this high since the 1999 measurements.

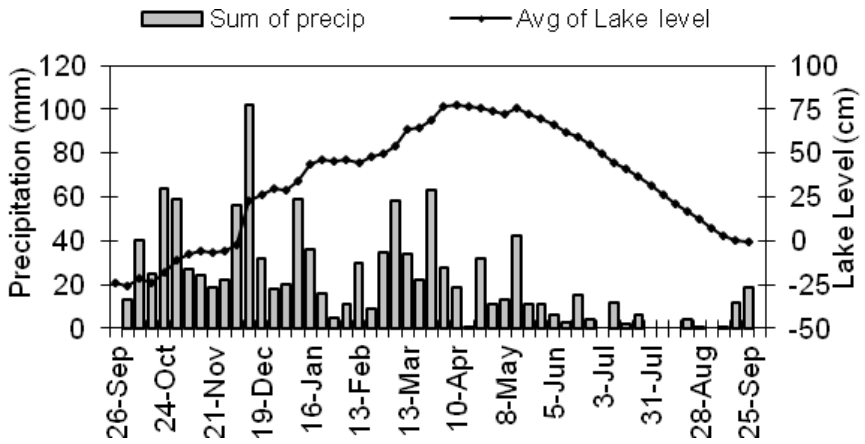

Figure 1. Angle Lake precipitation and lake level, WY2011

Lake levels appear to be increasing overall since the average low recorded in 2005 Figure 2). This year was similar to lake levels seen in the late 1990s and 2000. However, water levels in future years need to be documented in order to calculate whether or not the trend is statistically significant.

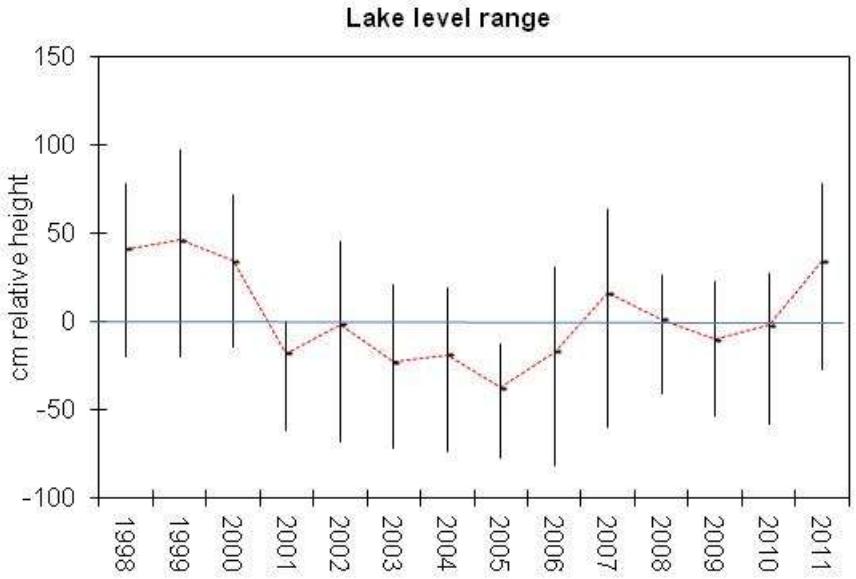

Figure 2. Each vertical line represents the range of lake levels recorded each water year relative to a zero datum set by a meter stick affixed to a static dock (not floating).

Secchi transparency is a common method used to assess and compare water clarity over time. It is a measure of the water depth at which a black and white disk disappears from view when lowered from the water surface.

Angle Lake Level I volunteers collected weekly temperature and Secchi transparency data throughout the 2011 water year (Figure 3). A different Level II volunteer collected water samples for laboratory analyses from early May through late October, and at the same time made temperature and Secchi measurements. Secchi transparency measured by the Level I volunteer ranged between 3.3 m and 8.7 m, with an annual average of 5.6 m and a summer average of 6.7 m. The data from the Level II volunteer, measuring from May through October only, ranged from 5.2 to 7.6 m, with a summer average of 6.4 m. The shallowest Secchi reading is 2.8 meters, deeper than the 2010 minimum of 0.5 m. Last year an *Uroglena* algae bloom occurred in the late winter and spring that obscured Secchi transparency; however, there was no recurrence of such a bloom in 2011. Secchi levels reported in 2011 are similar to transparency measurements from years before 2010.

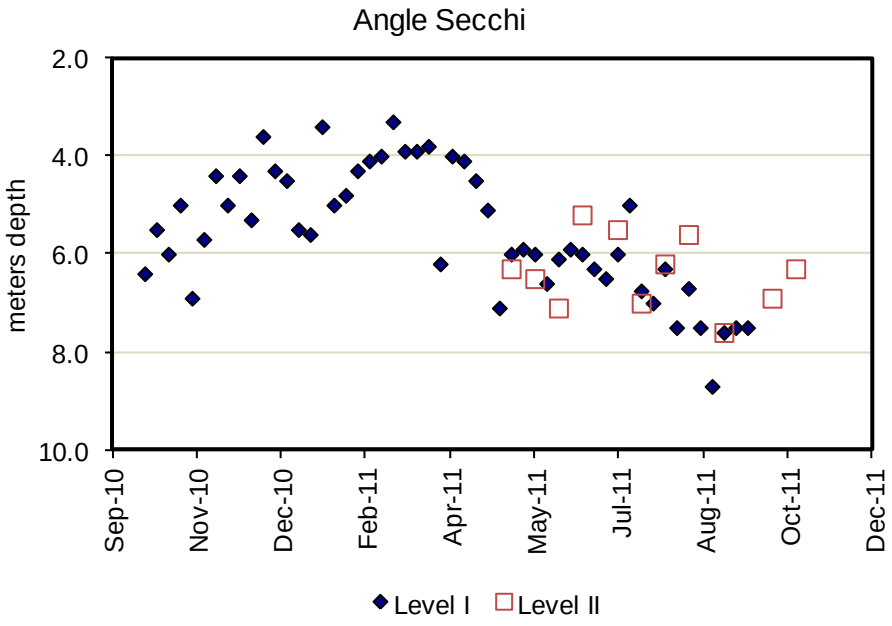

Figure 3. Angle Lake Secchi Transparency

Observers can vary in how they read the endpoint of the Secchi test, depending on their ability to differentiate subtle changes and how their vision reacts to glare off the water surface, the type of boat they are using, and how close to the water surface they can safely view the disk. Therefore, it is not surprising that there is a small systematic difference between the two observers, which also occurs among professionally trained field crews. It is important to be consistent in examining one observer's measurements over time and, if at all possible, to calibrate differences by collecting concurrent measurements between observers for comparison.

Water temperatures during the water year followed a pattern similar to other lakes in the region, with cool temperatures in the winter and spring, followed by summer maximum temperatures occurring between August and September, and temperatures cooling by late

September. All monitored area lakes were slower to warm in 2011, likely due to the very cool, wet spring. Angle Lake temperatures ranged from 5.0 to 23.0 degrees Celsius over the year with an average temperature of 13.0 degrees Celsius (Figure 4).

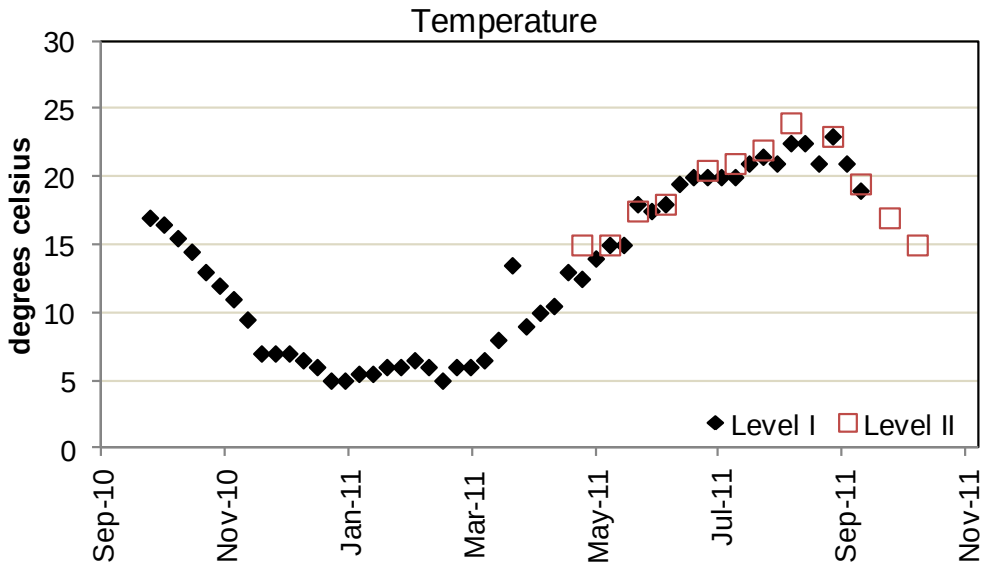

Figure 4. Angle Lake Water Temperatures

Nutrient and Chlorophyll Analysis

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential and commercial development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is in general limited by the amount of available phosphorus. Increases in phosphorus concentrations thus can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

Total phosphorus (TP) and total nitrogen (TN) varied little throughout the May – October sampling period (Figure 5) in 2011. One small peak occurred in the TP measurement during May.

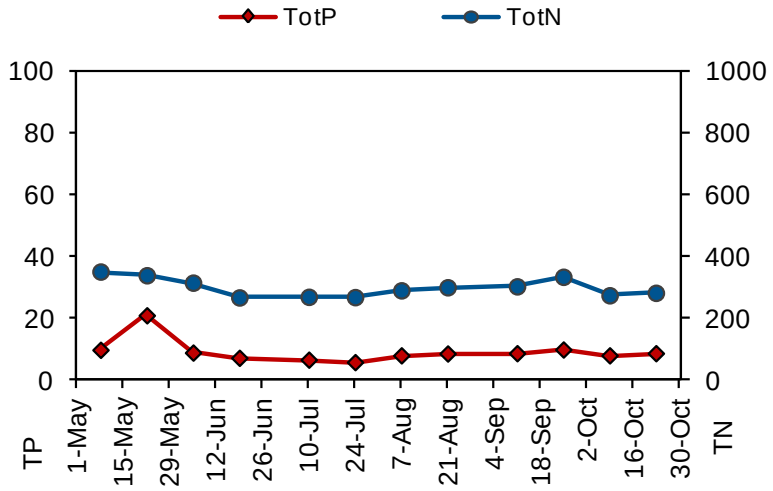

Figure 5. Angle Lake Nutrients

The ratio of nitrogen (N) to phosphorus (P) can be used to determine if conditions are favorable for the growth of cyanobacteria (bluegreen algae) that can impact beneficial uses of the lake. When N:P ratios are near or below 20, cyanobacteria can dominate the algal community due to their ability to take nitrogen from the air. The N:P ratio in Angle Lake for this water year ranged from 16.2 to 47 with an average ratio of 35.3. The minimum ratio value was in May, which coincides with the peak of TP. This is the lowest the N:P ratio got over the course of the summer months, suggesting that during part of May conditions might have favorable for bluegreen algae blooms, but it was not sustained. The last time the N:P ratio was this low was during the 2006 water year, where the N:P ratio went to 15.6 in September. If Angle Lake has a N:P ratio below 20 it is typically for only one week, suggesting that during most of the summer, conditions are not favorable for bluegreen algae blooms.

Chlorophyll *a* values were low from late spring through early fall at Angle Lake (Figure 6), although values began to climb through late September and October, indicating algal abundance increased in fall. Phytoplankton populations thus remained relatively low through the majority of the sampling season, and only increased in the fall. Pheophytin, which is a degradation product of chlorophyll, remained at or below detection limits throughout the season.

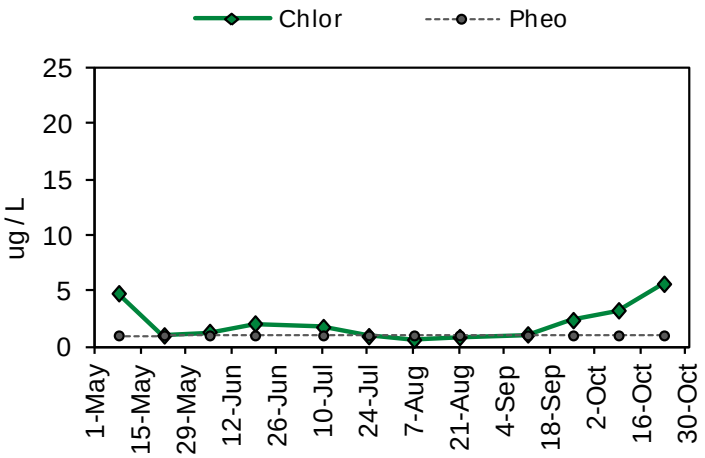

Figure 6. Angle Lake Chlorophyll *a* and Pheophytin Concentrations

Profile data indicate that thermal stratification was present early in the season and persisted through the summer (Table 1). In May, the deep water samples had significantly lower temperatures, as well as elevated levels of nutrients and detectable ammonia, all of that suggest that the hypolimnion (bottom water) of Angle Lake becomes anoxic during summer, facilitating internal phosphorus release from the sediments. This is confirmed by the NH3 (ammonia) concentrations and OPO4 (dissolved phosphorus) present in the deeper water. The increase in chlorophyll between 1 m and 8 m suggests that there may be more algae at intermediate water levels than at the surface, and this is more prominent in 2011 than in 2010 when the chlorophyll differences were smaller.

Table 1: Angle Lake Profile Sample Analysis Results. Sample values below minimum detection level are marked <MDL.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Angle	5/22/11	6.5	1	15.0	1.0	0.1	0.339	0.009	0.0209	0.0020	0.044	13.2
Angle	5/22/11		8	13.0	2.6	0.1	0.361		0.0119			
Angle	5/22/11		15	8.0			1.060	0.202	0.1240	0.0045		
Angle	8/21/11	5.6	1	24.0	0.9	1.0	0.300	<MDL	0.0085	0.0020	0.041	18.0
Angle	8/21/11		8	21.0	3.8	1.0	0.282		0.0070			
Angle	8/21/11		15	7.0			0.293	<MDL	0.0262	0.0020		

The relatively low values for UV254 indicate that the water of the lake is clear, with little coloration from organic substances. The total alkalinity values show that the water in the lake is soft and only very lightly buffered from pH change, thus sensitive to acidification.

The Trophic State Index

A common method of tracking water quality trends in lakes is through calculation of the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI values predict the biological productivity of the lake based on water clarity (Secchi) and concentrations of TP and chlorophyll *a*.

The 2011 TSI indicator values for Secchi and chlorophyll *a* were close to each other in the upper range of oligotrophy, while the TP indicator is slightly lower in the mid range of oligotrophy (Figure 7). For Angle Lake the average of the three TSI values are solidly in the oligotrophic range. An upward trend in values seen between the years 1997

through 2007 was reversed in 2008, increased in 2009 and 2010 but decreased in 2011. No trend can be statistically validated for the TSI values for either total phosphorus or the average of all 3 indicators. The ups and downs may be be year-to-year variation without direction, evidence of a cyclical pattern, or a true upward trend with a few unusual years superimposed, and only time will determine if there is any trend or pattern.

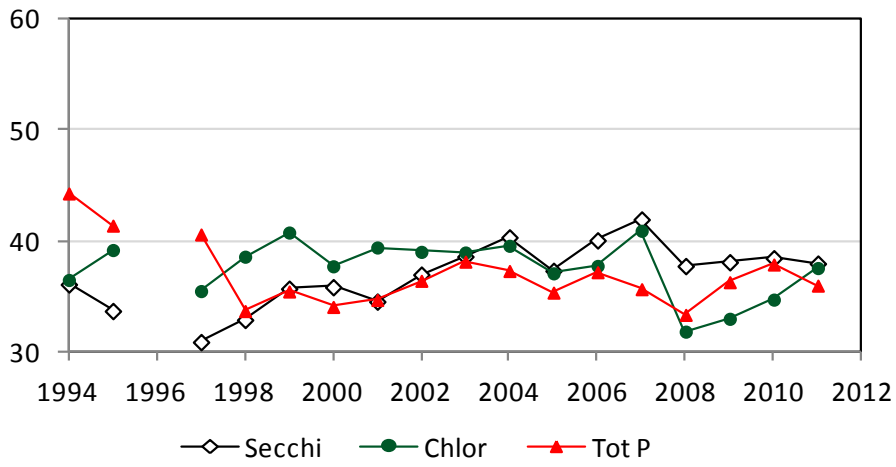

Figure 7. TSI Values at Angle Lake

Conclusions and Recommendations

Based on monitoring data, water quality in Angle Lake appears likely to be relatively stable over the last decade, but a slow, long-term increase in algae productivity cannot be ruled out. Nutrients in the lake remain in low concentrations through the season, and the majority of the N:P ratios are high, which makes the conditions in the lake generally unfavorable for bluegreen cyanobacterial blooms. Continued monitoring of nutrient and chlorophyll concentrations will track conditions to ensure that water quality remains consistent in Angle Lake over time.

The water level measurements in Angle Lake suggest that water levels have been increasing over the past several years from a low in the 2005 water year. The last two years could be contributed to back-to-back la Nina weather patterns hitting the northwest or it could suggest that the hydrologic budget of Angle Lake is changing.

The long term monitoring that the volunteers at Angle Lake have performed over the last decade has created an impressive dataset that tells the story of water quality and quantity for Angle Lake. Continued monitoring will help build on this dataset, increasing our understanding of how the lake responds to weather events and changes in the watershed, which is very small relative to the size of the lake.